

A Performance Analysis of Video Compression Standards MPEG & H.264

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Abstract

Due to the advent of multimedia computing, the demand for the videos has increased, their storage and manipulation in their raw form is very expensive and it significantly increases the transmission time and makes storage costly. When an ordinary analog video sequence is digitized, it can consume up to 165 Mbps. With most surveillance applications infrequently having to share the network with other data intensive applications and data transfer of uncompressed video over digital networks requires very high bandwidth. To circumvent this problem, a series of techniques called video compression techniques have been derived to reduce the number of bits required to represent a digital Video data while maintaining an acceptable fidelity or Video quality. The objective is to analyze and compare the video coding standards such as MPEG (Moving Picture Expert Group) and H.26X family.

Keywords: H.264, MPEG, PSNR

I. INTRODUCTION

Video coding is the process of compressing and decompressing a digital video signal. Coding of video is performed frame by frame. Each frame to be coded is first partitioned into a number of slices. Slices are individual coding units in this standard as compared to earlier standards as each slice is coded independently. The hierarchy of video data organization is illustrated in figure 1. Video compression technologies are about reducing and removing redundant video data so that a digital video file can be effectively sent over a network and stored on external storage disks. In video compression, the same process is performed except that video compression is performed for more than one frame. The encoder uses decoder for finding redundancy in future frames. Video compression is classified as block based video coding, object based video coding, Segmentation based video coding, Semantic based video coding, Texture based video coding knowledge based video coding, etc. The most popular MPEG-4 video codec uses object based video coding technique and the latest H.264/AVC uses block based video codec. Several important standards like Moving Picture Experts Group (MPEG) standard, H.261, 263 and 264 standards are the most commonly used techniques for video compression.

A video compression system consists of the following:

- An Encoder
- Compressed Bit Streams
- A Decoder

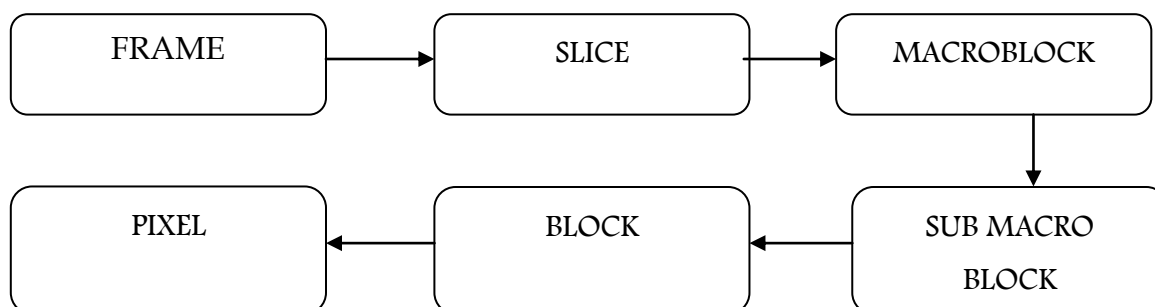


Figure 1. Organization of Video Data

A video compression system consists of the following:

- An Encoder
- Compressed Bit Streams
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II. VIDEO COMPRESSION

Spatial Redundancy

It is the correlation between pixels which might be near to each other in space.

Temporal Redundancy

It is described as the correlation among pixels which are close to one another in time.

Marcoblock (MB)

A location of size sixteen x 16 in the luminance part of the body and the corresponding region of chrominance element (eight x 8 places).

Intra prediction

A prediction in which the body content material of a MB region is represented without reference to a region in any formerly decoded body.

Motion Vector (MV)

A spatial displacement offset to be used in the prediction of picture vicinity.

Inter prediction

A prediction in which the body content material of a MB place is represented because the sum of a movement-reimbursement prediction the use of a movement vector and optionally a decoded residual difference signal illustration.

Motion Compensation (MC)

An interpreting technique that represents movement in each area of a frame via transmitted MVs of the previous decoded frame. To boom the accuracy of maximum inter prediction, a simple way is to account for the frame-to-body motion of gadgets. This procedure is known as MC.

Motion Estimation (ME)

It's far an encoding procedure that selects the MVs to be used for movement reimbursement. ME is the key to MC. In ME, the motion of each MB is measured and encoded into a movement vector. The vector is selected to limit the error among the associated MB pixels and the prediction pixels inside the reference frame.

I- Frame: A frame wherein all MBs of the body are coded the usage of Intra prediction. I-frame or "Intra coded" body describes a full still photo, containing handiest references to it. A video circulate may additionally encompass simplest one I- body. The primary body of a sequence is always I- body. I- frames typically resemble Joint pics professionals organization (JPEG) encoded pics and are perfect starting factors for the technology of prediction residuals.

P- Frame: P- Frames or "anticipated coded" frames use one or greater lately decoded frames as a reference (or prediction) for frame creation. The prediction is normally not precisely the same as the real body content material, so a residual may be delivered.

B- Frame: B- Frames or "Bi-directionally expected" frames work like P- frames with the exception that former and future I- or P- frames may be used as reference frames. For this to paintings, B- frames must be decoded after the following I- or P- frames.

III. NEED FOR VIDEO COMPRESSION

Table 2 Typical Uncompressed Video Data Rate

Format	Spatial Resolution	Frames/Second	Uncompressed Data Rate (bits/s)
QCIF	176 × 144	15	4 561 920
CIF	352 × 240	30	30 412 800
ITU-R601	720 × 480	30	124 416 000
HDTV	1280 × 720	30	331 776 000
HDTV	1920 × 1080	30	746 496 000

Full length, complete movement video requires a computer to supply statistics at 30 MB according to second. Today's more modern computer systems can manage this; however it results in video documents inside the gigabyte variety for only some mins of video. Even supposing the laptop can system the statistics, such large documents are impractical for garage and transfer. That is especially critical for files with the intention to be transferred over the internet. Compression creates a brand new document that stores records in a format that requires much less area. In a few cases the compressed document can later be decompressed or expanded.

Table 2: RAW Video Formats and Uncompressed Video Size

Format Name	Pixel Resolution (width x height)	Uncompressed Video Size
SQCIF (Sub-Quarter-CIF)	128 x 96	144 Kb
QCIF(Quarter – CIF)	176 x 144	297 Kb
CIF	352 x 288	1.16 Mb
DCIF	528 x 384	2.32 Mb
2CIF	704 x 288	2.32 Mb
4CIF	704 x 576	4.64 Mb
D1	720 x 576	4.75 Mb
16 CIF	1408 x 1152	18.56 Mb

***CIF – Common Intermediate Format**

Table 1 and 2 shows the required storage space and the bandwidth necessary for a video sequence. Hence it is crucial to reduce the size for both storage and transmission.

IV. Types of Compression Standards:

The standard formats for video compression such as the Mpeg methods and the recommended methods such as H.26x family are also used widely. MPEG standards are again developed periodically to meet the required demands with the progress of time such as MPEG-1, MPEG-2, MPEG-4, MPEG-7, etc....H.26X family such as H.261, H.263, and H.264

Goals of Standards:

- Ensuring interoperability- Enabling communication between devices made by different manufacturers.
- Promoting a technology or industry.
- Reducing Costs

4.1 MPEG 1:

The first public standard for the Moving Picture Experts Group (MPEG) committee was the MPEG-1. The MPEG-1 standard is published as ISO/IEC 11172. It has no direct provision for interlaced video applications. A standard for storage and retrieval of moving pictures and audio on storage media. It is designed to compress VHS-quality raw digital video and CD audio down to 1.5Mbit/s (26:1 and 6:1 compression ratios respectively) without excessive quality loss, making video CDs, digital cable and digital audio broadcasting possible. The standard consists of the following five parts.

- Systems (storage and synchronization of video, audio and other data together)
- Video (compressed video content)
- Audio (compressed audio content)
- Conformance testing
- Reference Software

Applications:

The popularity of MP3 audio has established a massive installed base of hardware that can play back MPEG-1 Audio.

4.2 MPEG 2:

The MPEG-2 project was approved in November 1994, focused on extending the compression technique of MPEG-1 to cover larger pictures and higher quality at the expense of higher bandwidth usage. The MPEG-2 standard is published as ISO/IEC 13818. MPEG-2 is designed for digital television broadcasting applications that require a bit rate typically between

4 and 15 Mbps (up to 100 Mbps), such as Digital high definition TV (HDTV), Interactive Storage Media (ISM) and cable TV (CATV). Profiles and levels were introduced in MPEG-2. This Standards consists of the following 10 parts.

- **Part 1:** Combine video and audio data into single/multiple streams
- **Part 2:** Offers more advanced video compression tools
- **Part 3:** Is a multi-channel extension of the MPEG-1 Audio standard
- **Part 4/5:** Correspond to and build on part 4/5 of MPEG-1
- **Part 6:** Specifies protocols of managing MPEG-1 & MPEG-2 bit streams
- **Part 7:** Specifies a multi-channel audio coding algorithm
- **Part 8:** 10-bit video extension. This part has been withdrawn due to lack of interest by industry
- **Part 9:** specifies the Real-time Interface (RTI) to Transport Stream decoders
- **Part 10:** the conformance part of Digital Storage Media Command and Control

4.3 MPEG 4:

MPEG-4 is a method of defining compression of audio and visual digital data. MPEG-4 is still an evolving standard and is divided into a number of parts. The familiar parts for people include MPEG-4 Part 2, MPEG-4 part 10 (MPEG-4 AVC/H.264 or Advanced Video Coding). It was approved in October 1998 and it enables multimedia in low bit-rate networks and allows the user to interact with the objects. Video object coding is one of the most important features introduced by MPEG-4. By compressing an arbitrarily shaped video object rather than a rectangular frame, MPEG-4 enables the possibility to manipulate and interact with the objects after they are created and compressed. The compression of an arbitrarily shaped video object includes the compression of its shape, motion and texture.

MPEG-4 enables different software and hardware developers to create multimedia objects possessing better abilities of adaptability and flexibility to improve the quality of such services and technologies as digital television, animation graphics, the World Wide Web and their extensions.

MPEG4 Features:

- Be able to encode mixed media data including video, audio and speech.
- It has improved coding efficiency over MPEG-2
- Be capable of interacting with the audio-visual scene generated at the receiver.
- Error resilience to enable robust transmission

Table: 3 MPEG standards

S.No	Year	Standard	Publisher	Popular Implementation	Bit Rate
1	1992	MPEG-1	ISO	Video-CD	1.5 Mb/s
2	1994	MPEG-2	ISO,ITU-T	DVD video,digital video broadcasting	>2Mb/s
3	1998	MPEG-4	ISO	Video in internet,DivX	Variable

4.4 H.261:

It was developed in 1990 by the International Telecommunication Union (ITU) developed the H.261 standard for data rates that are multiples of 64 Kbps. H.261 standard uses motion compensated temporal prediction. It supports two resolutions, namely, Common Interface Format (CIF) with a frame size of 352x288 and quarter CIF (QCIF) with a frame size of 172x144. H.261 describes the video coding and decoding methods for the moving picture component of audiovisual services at the rate of $p \times 64$ kbit/s, where p is in the range 1 to 30. H.261 encoding is based on the discrete cosine transform (DCT) and allows for fully-encoding only certain frames (INTRA-frame) while encoding the differences between other frames (INTER-frame). The main elements of the H.261 source coder are prediction, block transformation (spatial to frequency domain translation), quantization and entropy coding. Loop filtering provides a noticeable improvement in video quality but demands extra processing power. Two types of image frames are defined: Intra-frames (I-frames) and Inter-frames (P-frames) I frames are treated as independent images.

Applications:

H.261 is the most important application in the video conferencing and video communications systems. Its uses include studio based video conferencing, desktop video conferencing, surveillance, monitoring, computer training and tele-medicine.

4.5 H.263:

H.263 is a video compression standard originally designed as a low-bit-rate compressed format for videoconferencing. It was developed by the ITU-T Video Coding Experts Group (VCEG). H.263 standard is intended for

video telecommunication. It was approved in early 1996. H.263 is also the compression core of the MPEG-4 standard. The key features of H.263 standard were variable block size compensation, overlapped block motion compensation. The development of modems allowing transmission in the range of 28-33 kbps paved the way for the development of an improved version of H.261. H.263 can achieve better video at 18-24 Kbps than H.261 at 64 Kbps and enable video phone over regular phone lines or wireless modem. H.263 also found many applications on the internet: Flash Video Content. The original version of the RealVideo codec was based on H.263. H.263 standard supports five resolutions: QCIF, CIF, SQCIF, 4CIF, and 16 CIF.

4.6H.264:

H.264 or MPEG-4 Part 10, Advanced Video Coding (MPEG-4 AVC) is a block-oriented motion-compensation-based video compression standard. H.264 was developed by the ITU-T Video Coding Experts Group (VCEG) together with ISO/IEC. H.264 is perhaps best known as being one of the video encoding standards for Blu-ray Discs; all Blu-ray Disc players must be able to decode H.264. H.264 encoder provides the majority of significant improvement in compression efficiency in relation to the previous standards. H.264 is perhaps best known as being one of the video encoding standards for Blu-ray Discs; All Blu-ray Disc players must be able to decode H.264.

H.264 is a broad open standard with many suggested (but not mandatory) tools. This means that from one implementation to another, there can be a wide difference in the resulting compression rate. The various sets of capabilities, referred to as profiles, are intended for different industries and markets. The intent of using H.264 is to achieve very high data compression results. This standard is capable of providing better image quality at bit rates that are substantially lower than previous standards. The H.264 compression standard can reduce image size by up to 50% compared to MPEG-4, reducing the use of network bandwidth and storage; a significant gain particularly with high-motion video.

H.264 Features:

- Has higher coding efficiency
- Can provide high-quality video images at the low bit rate as well as the low bandwidth
- H.264 can work in real-time communication application low-latency mode, such as video conferencing
- Has less encoding options than H.263

Table 4: H.26X Family Standards

S.No	Year	Standard	Publisher	Popular Implementation	Bit Rate
1	1900	H.261	ITU-T	Video conferencing, video telephony	P*64 kb/s
2	1995	H.263	ITU-T	Video conferencing, videotelephony, video on mobile phones	<33.6 kb/s
3	2003	H.264	ISO, ITU-T	Blu-ray, DVD, digital video broadcasting, HDTV, iPad video, Apple TV	10's to 100's kb/s

V. PERFORMANCE METRIC

5.1 PSNR

The amount of information loss is expressed as a function of the original image (o) and the compressed bit-stream (c) and subsequently the reconstructed image (d). Mean Squared Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the most commonly used visual quality measures for image compression.

$$PSNR = 10 \log_{10} \left(\frac{L^2}{MSE} \right) \quad (1)$$

The MSE is the cumulative squared error between the reconstructed and the original image defined by,

$$MSE = \sum_{i=1}^M \sum_{j=1}^N \left(\frac{o(i, j) - d(i, j)^2}{M * N} \right) \quad (2)$$

Where, M and N are the dimension of image and L is the maximum gray level of the image. A lower value for MSE means lesser error, and as seen from the inverse relation between MSE and PSNR, this translates to a high value of PSNR. The PSNR value is expressed in db (decibels).

Table 5. PSNR Values of MPEG -4 & H.264

File Name	MPEG 4	H.264
Carboy	28.1385	33.1415
Newsreader	32.2324	38.2357
Claire	31.1501	35.1521
Suzie	30.1953	34.1924

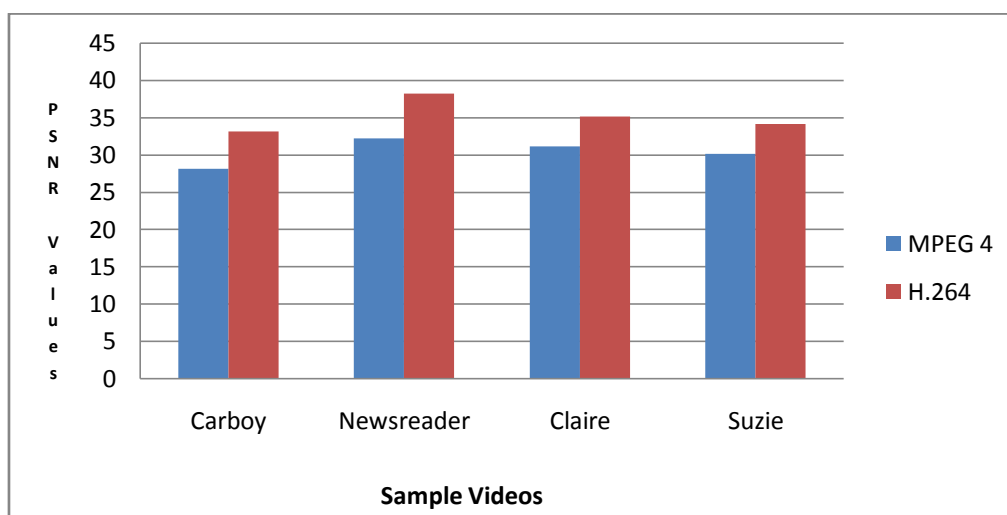


Fig 2 Comparison of PSNR values for MPEG -4 and H.264

6. CONCLUSION

The various video compression techniques are analyzed. Their performance is measured with PSNR (PEAK SIGNAL NOISE RATIO) metric. The video compression standard MPEG and H.264 are analyzed and compared. With respect to PSNR the H.264 gives a better result than the MPEG-4 technique.

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